Gallery of Geology
Union County glacier

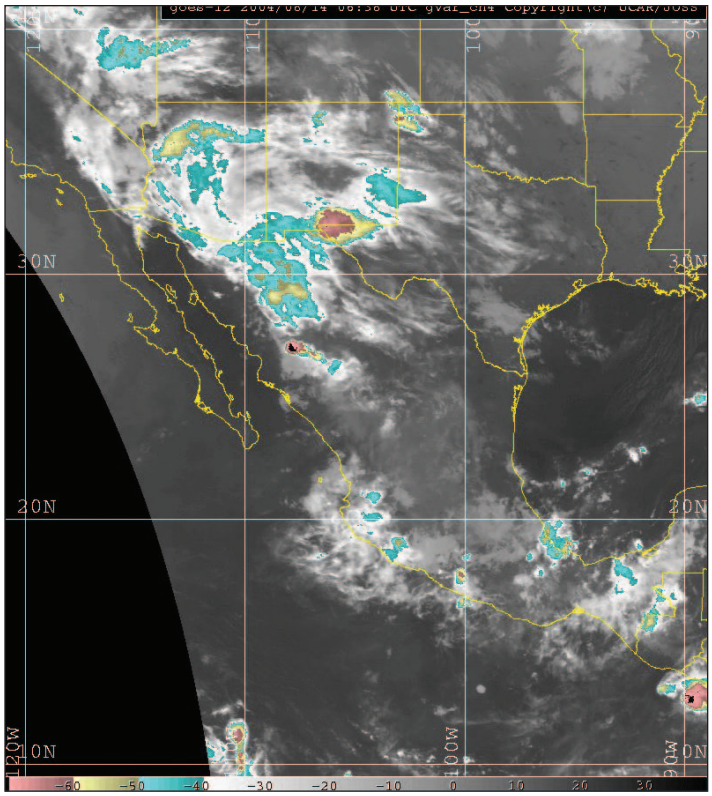

FIGURE 1—Infrared satellite image taken at 12:38 AM 13 August 2004 of southwestern United States and Mexico. Yellow and orange colors represent cloud tops colder than –50 °C. Orange speck near New Mexico–Oklahoma–Texas border represents the top of the intense thunderstorm that affected the Sedan area. From NOAA/National Weather Service courtesy of UCAR Joint Office for Science Support.

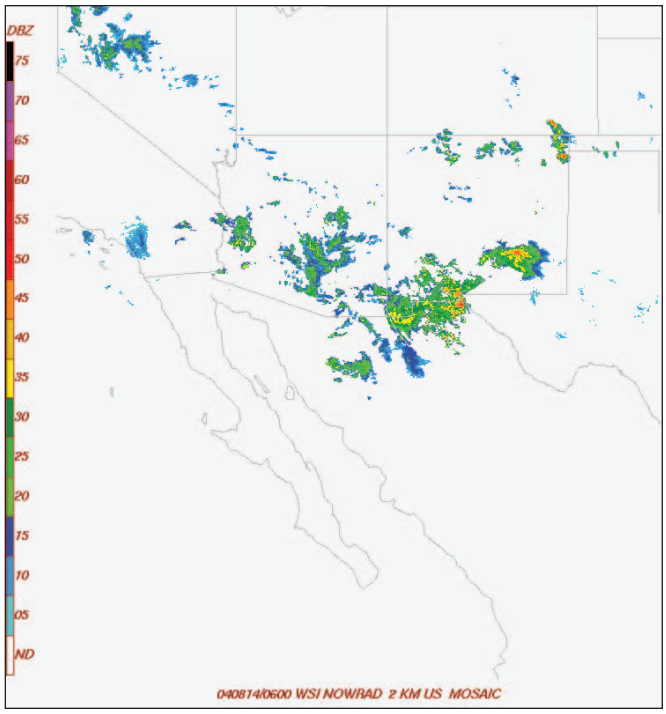

FIGURE 2—Regional radar mosaic of southwest United States and Mexico. Color scale on left side of image represents reflectivity or the strength of the radar returns. Red and pink colors represent hail cores within thunderstorms—the higher the reflectivity the larger the hail. From NOAA/National Weather Service courtesy of UCAR Joint Office for Science Support.

July and August are typically the wettest months for large parts of New Mexico because summer monsoon weather patterns bring moist winds up from the Gulf of Mexico and the Gulf of California. This is particularly true in eastern New Mexico. Union County, however, experienced unusually wet and cool weather during the summer months of 2004. From early June to the middle of August nearly 12 inches of rain were reported in some areas of the county (Table 1). The average summer temperature (highs and lows averaged from June through August) was 2.4° below normal, which is fairly significant for the average temperature.

Early in the month of August a succession of four cold fronts moved down from the north, helped along by a high-pressure cell stalled over Alaska. The cold fronts met humid gulf air moving up from the south and east, and every time the two met the unstable humid air was lifted resulting in bands of intense thunderstorms across the eastern plains. On August 11 a particularly strong cold front swept into the eastern high plains, lifting humid air laden with fresh moisture. Showers and many thunderstorms were reported across the state between August 11 and August 14. The most severe storms, including reports of large hail, occurred between the 12th and the 14th (Figs. 1 and 2).

TABLE 1—Rainfall for Clayton, New Mexico, during the summer 2004.

Month	Total rainfall (inches)
June	4.89
July	3.57
August	4.08

Residents of Clayton and Sedan, the town about 20 mi to the south, and areas in between will long remember the storm that hit around midnight on Friday the 13th and its spectacular aftermath. What the storm lacked in size (estimated at approximately 5 mi^2) it more than made up for in intensity. Hail accumulations reaching 12 inches were followed by as much as 5 inches of rain. So much rain fell in such a short period of time that the pea- and marble-sized hail was carried along first as sheetflood and then concentrated in a small drainage tributary to Sand Draw (Fig. 3) estimated to be approximately 15–20 ft deep. Approximately 8 mi south of Clayton just off NM–402 (sec. 10 T24N R35E), the hail began piling up behind a 12–16 ft culvert that was unable to handle the flow. Hail filled the small draw, as rain continued to flow across the fields, through the tons of ice, and onto the highway.

Very early Saturday morning a sleepy Barbara Podzemny got a phone call: "Drive north on NM–402, and bring your camera!" At their place near Sedan, Barbara and her husband Randy got only about an inch of rain during the night, and no hail, yet they drove north toward Clayton and photographed what for all the world

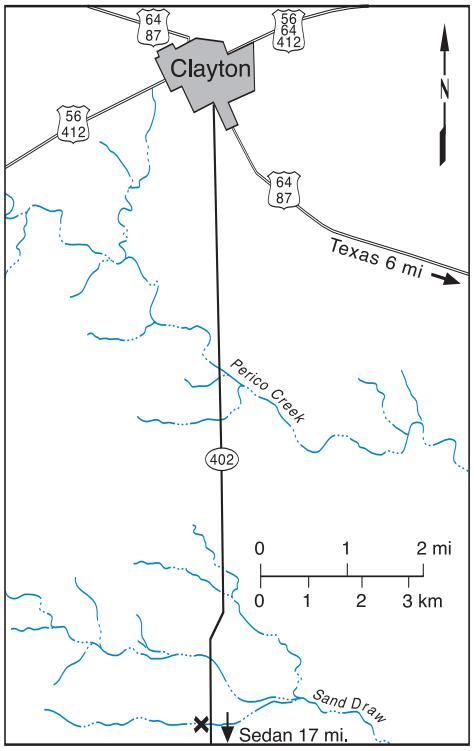

FIGURE 3—Map of northeast New Mexico showing location of August 13th hailstorm.

FIGURE 4—Overview looking west at hail accumulation in a tributary to Sand Draw approximately 8 mi south of Clayton. The hail was concentrated into an ice sheet estimated to be 100 yds long, 25 ft wide on either side of the channel, and 15 ft thick.

looks like a glacier in Union County. Hail had literally filled the draw to a height of approximately 15 ft. Saturday morning vertical ice cliffs as wide as 25 ft and 100 yds long framed the torrent of water flowing through the typically dry draw (See Figs. 4–9).

Late Sunday Louis King with the National Resources Conservation Service (NRCS) visited the site. A little girl who was happily excavating the ice with a small pail and shovel uncovered a 1-ft-long ringneck snake. It was steely gray on its back, and the orange coloring on its belly wrapped around the back of its head. The tiny snake was put into a jar where it thawed and was later observed moving about.

Although hail is commonly formed in thunderstorms, the dimensions of this accumulation are unique. The ice remained for nearly a month in spite of long sunny summer days and temperatures into the 80s. In the "precipitating event" 2.28 inches of rain fell in Clayton on August 13th and 14th. On the 14th of August alone 1.87 inches of rain was recorded, the greatest 24-hour rain-

FIGURE 5—Water from the previous night's deluge and melting ice flows between ice cliffs as high as 15 ft. Randy Podzemny, who is 6 ft 5 inches tall, stands near the bottom of the draw. Note the bedding patterns in the ice from varying amounts of debris and soil deposited with the hail.

FIGURE 6—Looking west upstream from Figure 5.

FIGURE 7—View of an ice cave formed as water drains into the draw from fields to the south. Windmill just beyond hail accumulation is barely visible at the top of the photo.

FIGURE 8—Normally dry tributary draw to Sand Draw is a torrent of water Saturday morning following Friday night's hail and rainstorm.

FIGURE 9—More runoff from Friday night, August 13th, hail and rainstorm flowing north parallel to NM–402 and cascading into tributary arroyo.

fall amount at Clayton all summer and a new record daily maximum precipitation amount for that date. The old record was 1.30 inches in 1926.

Acknowledgments

I would like to thank those individuals who provided the photographs and information about the night of August 13th and the days that followed: Barbara Podzemny, Louis King (NRCS), Kerry Jones, Keith Hayes, and Deirdre Kann with the National Weather Service in Albuquerque, and Mary Eakes and Sandra J. Powers of the Union County Leader. I also thank those who forwarded the spectacular photos to colleagues via the internet. Web-based reports on this and other unusual weather events can be found on the NOAA Web site, www.srh.noaa.gov/abq

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Hail strikes Socorro

Hail collected in the Bureau of Land Management parking lot in Socorro. Photo by Edward Wells.

October 5th is well past the end of summer and presumably the end of summer storms, but this continues to be the year of unusual weather. On October 4th and 5th several severe storms containing large hail moved through the Albuquerque area, and on the 5th were reported in Belen and Socorro; near Encino, Picacho, Vaughn, and Lovington; and between Dexter and Hagerman. At New Mexico Institute of Mining and Technology in Socorro, hail between 2 and 3 inches in diameter bombarded buildings and vehicles causing more than $10 million in damage on the campus. Estimates of storm damage city wide were at least $10 million as well.

I calculated that the terminal velocity achieved by a 2-inch-diameter spherical hailstone would be 78 mph, whereas a 3-inch-diameter hailstone would hit the ground at more than 95 mph. The more typical pea-sized hail, if it were assumed to be one-fifth inch in diameter, would reach a terminal velocity of slightly over 25 mph. A comparison of momentum transferred on impact shows that the 3-inch hail packed more than 3,500 times the momentum of one-fifth-inch hail.

These fierce terminal velocities of 80–95 mph are identical to the updraft velocities necessary to create 2–3-inch-diameter hail. In fact updraft velocities actually exceed 95 mph because air density is lower at the elevation where hail is created. [I made these calculations using a simple newtonian drag model, in which drag force is proportional to velocity cubed and the cross sectional area of the falling object. Hail density was taken to be 920 kg/m^3, and air density at Socorro's elevation was taken to be 1.00 kg/m^3.]

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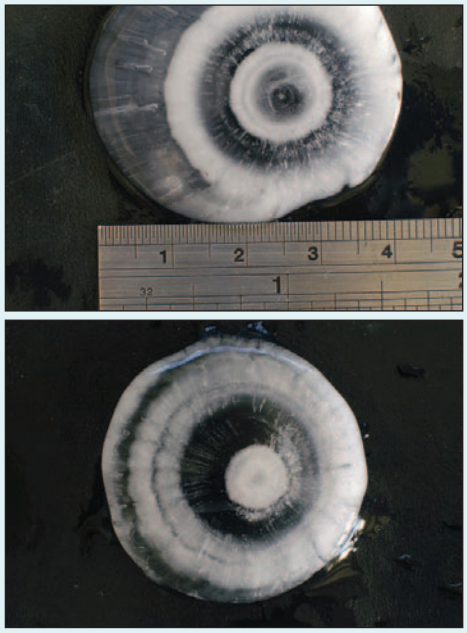

These hailstones have melted down from their 2-inch diameter to approximately 1.5 inches. Many 3-inch stones were observed as well. These pictures were selected because they so clearly depict the growth rings associated with hail formation. Photos by Harald Edens.